

# Smokeless tobacco use related to military deployment, cigarettes and mental health symptoms in a large, prospective cohort study among US service members

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## ABSTRACT

**Aims** To characterize smokeless tobacco initiation and persistence in relation to deployment, combat, occupation, smoking and mental health symptoms. **Design** Prospective cohort, utilizing self-reported survey data from the Millennium Cohort Study. **Setting** US military service members in all branches including active duty, reserve and National Guard. **Participants** Population-based sample of 45 272 participants completing both baseline (July 2001–June 2003;  $n = 77\,047$ ) and follow-up (June 2004–January 2006;  $n = 55\,021$ ) questionnaires (follow-up response rate = 71.4%). **Measurements** Self-reported smokeless tobacco initiation and persistence. **Findings** Over the study period, 72.4% did not deploy, 13.7% deployed without combat exposures and 13.9% deployed with combat exposures, while 1.9% were smokeless tobacco initiators and 8.9% were persistent users. The odds of initiation were greater for deployers with combat exposure [odds ratio (OR), 1.76; 95% confidence interval (CI), 1.49–2.09], deployers without combat exposure (OR, 1.31; 95% CI, 1.07–1.60) and those who deployed multiple times (OR, 1.67; 95% CI, 1.31–2.14), as well as in smoking recidivists/initiators (OR, 4.65; 95% CI, 3.82–5.66) and those reporting post-traumatic stress disorder symptoms (OR, 1.54; CI, 1.15–2.07). A similar pattern for higher odds of persistent use was observed for deployment and combat exposure, but not for smoking and mental health symptoms. Military occupation was not significantly associated with initiation or persistence. **Conclusions** Deployment and combat exposure in the US military are associated with increased risk of smokeless tobacco initiation and persistence while smoking and symptoms of post-traumatic stress disorder increase the odds for initiation. Research is needed on aspects of military service amenable to the reduction or prevention of tobacco consumption.

**Keywords** Afghanistan, Iraq war, military personnel, post-traumatic stress disorder, risk factors, smokeless tobacco, tobacco use disorder, veterans, war.

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## INTRODUCTION

Smokeless tobacco (ST) is the second most commonly used tobacco product in the United States. The past-month prevalence for ST use in the United States between 2002 and 2009 ranged from 3.0 to 3.5% [1]. ST use is more common in those aged 18–25 years and 15 times more common in men [2]. It has been implicated in

oropharyngeal, prostate and pancreatic cancers [3–5] and, ultimately, these health effects contribute to higher all-cause mortality rates compared with non-users [6].

Tobacco use is especially prevalent in the military and has been linked to poor training performance and early discharge [7–9]. Along with health concerns, these associations have led to a decline in use by military personnel since the 1980s. However, use in the military is still

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higher compared with the general population, which may be related to unique risk factors of military service. In 2005, 32.2% of military personnel reported smoking [10] compared with 24.9% in the general population [1].

In 2005, past-year ST use in the military was 14.5% overall and 21.6% in those aged 18–24 years compared with approximately 3% in the general population. This rate increased 2.3% between 2001 and 2005, indicating that the stresses of deployment and combat of the current conflicts may play a role in the prevalence of ST use [10]. Other studies have shown that factors related to ST initiation and smoking include stress, boredom and peer influence [11,12], in addition to a life-time history of stressors and psychiatric disorders [13,14].

The prospective nature of the Millennium Cohort Study, the largest longitudinal study undertaken by the US Department of Defense (DoD), provides a unique opportunity to investigate rates of ST initiation and persistent use. Our primary hypothesis was that these rates would increase in relation to deployment and combat exposure, while secondary hypotheses were that rates would also display an association with military occupation (a marker for peer influence), smoking status and mental health symptoms.

## METHODS

### Participants

Participants were enrolled into the Millennium Cohort Study, which was launched in 2001 to evaluate potential risk factors for health outcomes related to military service. A detailed description of the methodology can be found elsewhere [15,16]. In short, 214 388 participants in the first panel were contacted from a stratified random sample of the 2.2 million US military personnel on active, reserve or National Guard rosters in October 2000. Women, those with past deployment experience and reserve/National Guard members were oversampled. The current sample draws on individuals from the first panel who completed a baseline questionnaire between July 2001 and June 2003 ( $n = 77\,047$ , 37.0% initial response rate) and a follow-up questionnaire between June 2004 and January 2006 ( $n = 55\,021$ , 71.4% follow-up response rate).

The sample consisted of 45 272 individuals with an average age of 34.8 [standard deviation (SD) = 9.0], 73.1% of whom were male, while 48.4% were in the Army, 29.7% in the Air Force, 17.8% in the Navy/Coast Guard and 4.2% in the Marine Corps. These characteristics are consistent with similar investigations of the Millennium Cohort [17]. The institutional review board at the Naval Health Research Center approved this study, and written informed consent was obtained.

## Measures

### Smokeless tobacco use

ST use was measured using a single-item question that asks whether the participant had used smokeless tobacco (chew, dip, snuff) in the past year. Participants were categorized into four groups based on their response to this question at baseline and follow-up: non-users (responded 'no' at baseline and follow-up), new users (responded 'no' at baseline and 'yes' at follow-up), past users (responded 'yes' at baseline and 'no' at follow-up) and persistent users (responded 'yes' at both baseline and follow-up).

### Deployment

The primary deployment variable of interest categorized participants as deployed or non-deployed based on information obtained from the Defense Manpower Data Center (DMDC) and not susceptible to recall bias. Participants were categorized further by the number of deployments as well as reported combat exposures. Deployment frequency was categorized as (i) non-deployed: no record of deployment to Iraq or Afghanistan between the initial and follow-up questionnaire; (ii) deployed once: one deployment on record beginning prior to follow-up; and (iii) deployed multiple times: more than one deployment on record, with the second deployment beginning prior to follow-up. Combat exposure during deployment was based on affirmative responses to survey questions about witnessing any of the following: death due to war, disaster or a tragic event; instances of physical abuse; dead or decomposing bodies; maimed soldiers or civilians; or prisoners of war or refugees. Deployment prior to the conflicts in Iraq and Afghanistan was used as a covariate and categorized as deployment to (i) the 1991 Gulf War; (ii) Southwest Asia following the 1991 Gulf War until 2000, or Bosnia or Kosovo from 1998 to 2000; (iii) both 1 and 2; and (iv) neither 1 nor 2.

### Military occupation

Military occupational information was obtained at the time of study entrance from DMDC and is based on the primary occupational specialty assigned to military personnel. Occupation codes were grouped according to the *DoD Occupational Conversion Manual* [18] to describe similar occupations that span service component (active duty, reserve and National Guard), as well as service branch (Air Force, Army, Navy and Marine Corps). Categories were refined to examine specific occupations of interest: aircrew, other combat specialists (excluding aircrew), health care and other.

### Cigarette smoking

Cigarette smoking was assessed at baseline and follow-up by asking if participants had ever smoked more than 100

cigarettes in their life-time and if so, whether they had quit successfully. Participants were classified as never smokers, past smokers, recidivists/initiators and persistent smokers.

#### *Alcohol-related problem*

Alcohol-related problems were assessed with the five alcohol use questions from the Patient Health Questionnaire (PHQ) [19,20] and the four questions from the Cut-down, Annoyed, Guilt, Eye-opener (CAGE) questionnaire [21], all of which assess for problematic alcohol use. Participants were classified as potentially having an alcohol-related problem if they answered 'yes' to any of these questions.

#### *Stress and mental health symptoms*

Self-reported life stressors and mental health symptoms were measured at baseline. A history of major life events such as divorce/separation, financial problems, sexual assault, violent assault, severe illness and death of a family member or loved one were documented and categorized as low/mild or moderate/major using scoring from the Social Readjustment Rating Scale [22,23]. Past mental health diagnosis or treatment was indicated by self-report of a diagnosis of depression, schizophrenia or psychosis, manic-depressive disorder or post-traumatic stress disorder (PTSD), or reported use of medication for anxiety or depression. Symptoms of PTSD at baseline were evaluated using the PTSD Checklist—Civilian version [24,25], a 17-item self-report measure of PTSD-related symptoms that asks respondents to rate the severity of each symptom during the past 30 days on a five-point Likert scale. Participants were identified as having PTSD symptoms if they reported a moderate or higher level of at least one intrusion symptom, three avoidance symptoms and two hyperarousal symptoms.

#### *Demographics*

Demographic and military specific variables that have been shown to potentially influence ST use in past studies, including sex, date of birth, education, marital status, race/ethnicity, pay grade, service component and service branch, were evaluated [1,2,7]. Data were obtained from DMDC and reflect status at baseline. Race/ethnicity was obtained from personnel records maintained by DMDC. Any missing demographic or military characteristic data were acquired from responses on the baseline Millennium Cohort questionnaire (less than 1% of data).

#### **Analytical plan**

Univariate and descriptive analyses were conducted to evaluate unadjusted associations between smokeless

tobacco use and deployment, occupation and all other covariates. Multivariable logistic regression models were used to evaluate two separate outcomes: newly reported ST use among participants who reported no use at baseline, and persistent ST use among participants who reported using ST at baseline. Regression diagnostics were conducted to identify multi-collinearity. Deployment variables for combat experience and deployment frequency could not coexist in the same model due to multi-collinearity; therefore, each outcome was modeled first, including the primary deployment variable of combat experience and all covariates, then re-run removing combat experience and inserting deployment frequency while retaining all other variables. All four regression models included all the covariates shown in Table 1 except for the multi-collinearity issues discussed above. Analyses were performed using SAS software, version 9.2 (SAS Institute, Inc, Cary, NC, USA).

## **RESULTS**

### **Sample size**

There were 55 020 participants from the first panel who completed both a baseline and follow-up questionnaire. Participants were excluded from the current analyses if any of the following data were missing: combat exposure ( $n = 175$ ), smokeless tobacco ( $n = 3349$ ), occupation ( $n = 3567$ ) or other covariate data ( $n = 2657$ ).

### **Descriptive analyses**

Among the remaining 45 272 participants, 32 760 (72.4%) were non-deployed, 6204 (13.7%) were deployed between baseline and follow-up without reporting combat exposures and 6308 (13.9%) were deployed with combat exposures (Table 1). When comparing deployment groups, all proportional differences were statistically significant using Pearson's  $\chi^2$  test ( $P < 0.001$ ). Although many of the differences in these proportions were small, there were exceptions worth noting. Younger, less educated, never-married men who were of Asian/Pacific Islander or other race/ethnicity, past or current smokers, reporting an alcohol-related problem, Army or Marine Corps personnel and categorized as other combat specialists, were proportionately more likely to be deployed with combat.

Four categories of ST use were assessed in relation to study characteristics (Table 2) and all proportional differences were statistically significant using Pearson's  $\chi^2$  test ( $P < 0.001$ ). Among participants, 878 (1.9%) reported new use while 4028 (8.9%) reported persistent use. When comparing new users and non-users, more extreme differences noted were among

**Table 1** Baseline characteristics of Millennium Cohort Study participants by deployment to Iraq and Afghanistan.

Characteristic <sup>b</sup>	Study sample n = (45 272) n (%)	Deployment between baseline and follow-up questionnaire <sup>a</sup>		
		Non-deployed n = (32 760) n (%)	Deployed without combat n = (6204) n (%)	Deployed with combat n = (6308) n (%)
Sex				
Female	12 161 (26.9)	9 899 (30.2)	1241 (20.0)	1021 (16.2)
Male	33 111 (73.1)	22 861 (69.8)	4963 (80.0)	5287 (83.8)
Birth cohort				
Pre-1960	10 997 (24.3)	8 930 (27.3)	1145 (18.5)	922 (14.6)
1960–69	18 377 (40.6)	13 223 (40.4)	2697 (43.5)	2457 (39.0)
1970–79	14 006 (30.9)	9 416 (28.7)	2055 (33.1)	2535 (40.2)
1980+	1 892 (4.2)	1 191 (3.6)	307 (5.0)	394 (6.3)
Education				
High school or less	20 341 (44.9)	14 441 (44.1)	2394 (38.6)	3506 (55.6)
Some college/bachelor's	20 067 (44.3)	14 379 (43.9)	3352 (54.0)	2336 (37.0)
Advanced degree	4 864 (10.7)	3 940 (12.0)	458 (7.4)	466 (7.4)
Marital status				
Never married	11 924 (26.3)	8 299 (25.3)	1669 (26.9)	1956 (31.0)
Currently married	30 129 (66.6)	22 005 (67.2)	4138 (66.7)	3986 (63.2)
No longer married	3 219 (7.1)	2 456 (7.5)	397 (6.4)	366 (5.8)
Race/ethnicity				
White non-Hispanic	32 435 (71.6)	23 537 (71.9)	4527 (73.0)	4371 (69.3)
Black non-Hispanic	5 476 (12.1)	4 067 (12.4)	740 (11.9)	669 (10.6)
Asian/Pacific Islander	3 744 (8.3)	2 560 (7.8)	459 (7.4)	725 (11.5)
Other	3 617 (8.0)	2 596 (7.9)	478 (7.7)	543 (8.6)
Smoking				
Never smokers	25 541 (56.4)	18 574 (56.7)	3613 (58.2)	3354 (53.2)
Past smokers	9 604 (21.2)	7 358 (22.5)	1192 (19.2)	1054 (16.7)
Recidivists/initiators	3 931 (8.9)	2 602 (7.9)	545 (8.8)	784 (12.4)
Persistent smokers	6 196 (13.7)	4 226 (12.9)	854 (13.8)	1116 (17.7)
Alcohol-related problem <sup>c</sup>				
No	35 297 (78.0)	25 712 (78.5)	4851 (78.2)	4734 (75.1)
Yes	9 975 (22.0)	7 048 (21.5)	1353 (21.8)	1574 (25.0)
PTSD symptoms <sup>d</sup>				
No	43 534 (96.2)	31 433 (96.0)	6048 (97.5)	6053 (96.0)
Yes	1 738 (3.8)	1 327 (4.1)	156 (2.5)	255 (4.0)
Past mental health diagnosis <sup>e</sup> or taking medication for anxiety, depression or stress				
No	41 406 (91.5)	29 639 (90.5)	5857 (94.4)	5910 (93.7)
Yes	3 866 (8.5)	3 121 (9.5)	347 (5.6)	398 (6.3)
Life stressors score				
Low/mild	38 239 (85.5)	27 303 (83.3)	5537 (89.3)	5399 (85.6)
Moderate/major	7 033 (15.5)	5 457 (16.7)	667 (10.8)	909 (14.4)
Military pay grade				
Officer	11 693 (25.8)	8 709 (26.6)	1428 (23.0)	1556 (24.7)
Enlisted	33 579 (74.2)	24 051 (73.4)	4776 (77.0)	4752 (75.3)
Service component				
Active duty	25 274 (55.8)	17 514 (53.5)	3829 (61.7)	3931 (62.3)
Reserve/National Guard	19 998 (44.2)	15 246 (46.5)	2375 (38.3)	2377 (37.7)
Branch of service				
Army	21 891 (48.4)	15 662 (47.8)	1923 (31.0)	4306 (68.3)
Air Force	13 454 (29.7)	9 193 (28.1)	3021 (48.7)	1240 (19.7)
Navy/Coast Guard	8 047 (17.8)	6 551 (20.0)	1077 (17.4)	419 (6.6)
Marine Corps	1 880 (4.2)	1 354 (4.1)	183 (3.0)	343 (5.4)



Table 1 Cont.

Characteristic <sup>b</sup>	Study sample n = (45 272) n (%)	Deployment between baseline and follow-up questionnaire <sup>d</sup>		
		Non-deployed n = (32 760) n (%)	Deployed without combat n = (6204) n (%)	Deployed with combat n = (6308) n (%)
Occupational category				
Health-care specialists	5 552 (12.3)	4 572 (14.0)	258 (4.2)	722 (11.5)
Aircrew	2 240 (5.0)	1 128 (3.4)	599 (9.7)	513 (8.1)
Other combat specialists	5 346 (11.8)	3 895 (11.9)	439 (7.1)	1012 (16.0)
Other	32 134 (71.0)	23 165 (70.7)	4908 (79.1)	4061 (64.4)
Pre-Iraq/Afghanistan <sup>f</sup>				
1991 Gulf War	3 649 (8.1)	2 700 (8.2)	366 (5.9)	583 (9.2)
SW Asia/Bosnia/Kosovo	11 302 (25.0)	7 060 (21.6)	2323 (37.4)	1919 (30.4)
Both	2 224 (4.9)	1 354 (4.1)	516 (8.3)	354 (5.6)
Neither	28 097 (62.1)	21 646 (66.1)	2999 (48.3)	3452 (54.7)
Number of deployments <sup>g</sup>				
Non-deployed	32 760 (72.4)	32 760 (100.0)	0 (0.0)	0 (0.0)
One deployment	6 204 (13.7)	0 (0.0)	4666 (75.2)	4915 (77.9)
Multiple deployments	6 308 (13.9)	0 (0.0)	1538 (24.8)	1393 (22.1)

PTSD: post-traumatic stress disorder. <sup>a</sup>Questionnaires were administered from 2001 to 2003 for the baseline assessment and 2004 to 2006 for the follow-up. <sup>b</sup>All differences in distribution by deployment status were statistically significant at  $P < 0.001$ . <sup>c</sup>Alcohol-related problem based on affirmative response to any alcohol question on the Patient Health Questionnaire or Cut-down, Annoyed, Guilt, Eye-opener (CAGE) questionnaire. <sup>d</sup>Post-traumatic stress disorder based on screening positive on the PTSD Patient Checklist—Civilian version using criteria from the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition. <sup>e</sup>Self-report of a physician diagnosis for depression, schizophrenia, psychosis or manic-depressive disorder. <sup>f</sup>Deployment prior to the wars in Iraq and Afghanistan includes the 1991 Gulf War, and Southwest Asia following the 1991 Gulf War, Bosnia or Kosovo from 1998 to 2000. <sup>g</sup>Both indicates deployment to 1991 Gulf War and Southwest Asia, Bosnia or Kosovo, while 'neither' implies not deployed to any of these operations. <sup>h</sup>Number of deployments to Iraq or Afghanistan between baseline and follow-up questionnaires.

younger, less educated, never-married men who were of white non-Hispanic race/ethnicity, smoking recidivists/initiators or persistent users, reporting an alcohol-related problem or symptoms of PTSD, enlisted, Army or Marine Corps personnel, categorized as aircrew or other combat specialists, previously deployed and combat-experienced. The comparison of persistent and past users was similar, except that persistent users were more likely to be slightly older, college-educated, currently married, never smokers, without PTSD symptoms and reserve/National Guard members.

### Multivariate analyses

When comparing ST initiators and non-users in multivariable logistic regression (Table 3), the odds of initiation were significantly greater for men, those born in 1960 or later. Other than never smokers, including smoking recidivists/initiators (OR = 4.65; 95% CI: 3.82–5.66) in addition to those with an alcohol related problem (OR = 1.21, 95% CI: 1.04–1.41) and those who report PTSD symptoms (OR = 1.54, 95% CI: 1.15–2.07).

Except for deployment prior to the wars in Iraq and Afghanistan, all measures of deployment were associated

significantly with ST initiation. Compared with non-deployers, the odds of ST initiation were greater among deployers with combat exposure [odds ratio (OR): 1.76, 95% confidence interval (CI): 1.49–2.09] and without combat exposure (OR = 1.31, 95% CI: 1.07–1.60). The odds were greater in those with multiple deployments (OR = 1.67, 95% CI: 1.31–2.14) compared with those with only one (OR = 1.53, 95% CI: 1.31–1.79). Conversely, those with an advanced degree, of black non-Hispanic or other race/ethnicity or who had served in the Air Force or Navy/Coast Guard were at significantly reduced odds for ST initiation.

When comparing persistent ST use with ST use at baseline only, men, those currently married, deployed with combat exposures or deployed one or more times were at significantly greater odds. Compared with non-deployment, a significantly higher odds of ST persistence was observed in combat deployment but not in deployment without combat exposure. Both single and multiple deployments when compared with non-deployment were associated with higher odds of ST persistence, with the greatest effect noted in the latter category. Those of black non-Hispanic, or other race/ethnicity, as well as past or persistent smokers were at significantly decreased odds for persistent ST use.

**Table 2** Characteristics of Millennium Cohort participants by smokeless tobacco use based on baseline (2001–03) to follow-up (2004–06) responses.

Characteristic <sup>a</sup>	Study sample ( <i>n</i> = 45 272) <i>n</i> (%)	Smokeless tobacco use			
		No use ( <i>n</i> = 38 993) <i>n</i> (%)	New use ( <i>n</i> = 878) <i>n</i> (%)	Past use ( <i>n</i> = 1373) <i>n</i> (%)	Persistent use ( <i>n</i> = 4028) <i>n</i> (%)
Sex					
Female	12 161 (26.9)	11 965 (30.7)	47 (5.4)	88 (6.4)	61 (1.5)
Male	33 111 (73.1)	27 028 (69.3)	831 (94.7)	1285 (93.6)	3967 (98.5)
Birth cohort					
Pre-1960	10 997 (24.3)	10 332 (26.5)	102 (11.6)	143 (10.4)	420 (10.4)
1960–69	18 377 (40.6)	15 925 (40.8)	322 (36.7)	488 (35.5)	1642 (40.8)
1970–79	14 006 (30.9)	11 259 (28.9)	383 (43.6)	622 (45.3)	1742 (43.3)
1980+	1 892 (4.2)	1 477 (3.8)	71 (8.1)	120 (8.7)	224 (5.6)
Education					
High school or less	20 341 (44.9)	16 551 (42.5)	531 (60.5)	829 (60.4)	2430 (60.3)
Some college/bachelor's	20 067 (44.3)	17 829 (45.7)	312 (35.5)	478 (34.8)	1448 (36.0)
Advanced degree	4 864 (10.7)	4 613 (11.8)	35 (4.0)	66 (4.8)	150 (3.7)
Marital status					
Never married	11 924 (26.3)	9 988 (25.6)	285 (32.5)	491 (35.8)	1160 (28.8)
Currently married	30 129 (66.6)	26 098 (66.9)	564 (64.2)	805 (58.6)	2662 (66.1)
No longer married	3 219 (7.1)	2 907 (7.5)	29 (3.3)	77 (5.6)	206 (5.1)
Race/ethnicity					
White non-Hispanic	32 435 (71.6)	27 126 (69.6)	717 (81.7)	1103 (80.3)	3489 (86.6)
Black non-Hispanic	5 476 (12.1)	5 302 (13.6)	41 (4.7)	53 (3.9)	80 (2.0)
Asian/Pacific Islander	3 744 (8.3)	3 285 (8.4)	67 (7.6)	115 (8.4)	277 (6.9)
Other	3 617 (8.0)	3 280 (8.4)	53 (6.0)	102 (7.4)	182 (4.5)
Smoking					
Never smokers	25 541 (56.4)	23 347 (59.9)	286 (32.6)	411 (29.9)	1497 (37.2)
Past smokers	9 604 (21.2)	7 972 (20.4)	169 (19.3)	370 (27.0)	1093 (27.1)
Recidivists/initiators	3 931 (8.9)	2 894 (7.4)	194 (22.1)	197 (14.4)	646 (16.0)
Persistent smokers	6 196 (13.7)	4 780 (12.3)	229 (26.1)	395 (28.8)	792 (19.7)
Alcohol-related problem <sup>b</sup>					
No	35 297 (78.0)	31 288 (80.2)	610 (69.5)	868 (63.2)	2531 (62.8)
Yes	9 975 (22.0)	7 705 (19.8)	268 (30.5)	505 (36.8)	1497 (37.2)
PTSD symptoms <sup>c</sup>					
No	43 534 (96.2)	37 576 (96.4)	818 (93.2)	1294 (94.3)	3846 (95.5)
Yes	1 738 (3.8)	1 417 (3.6)	60 (6.8)	79 (5.8)	182 (4.5)
Past mental health diagnosis <sup>d</sup> or taking medication for anxiety, depression or stress					
No	41 406 (91.5)	35 536 (91.1)	812 (92.5)	1265 (92.1)	3793 (94.2)
Yes	3 866 (8.5)	3 457 (8.9)	66 (7.5)	108 (7.9)	235 (5.8)
Life stressors score					
Low/mild	38 239 (85.5)	32 741 (84.0)	772 (87.9)	1189 (86.6)	3537 (87.8)
Moderate/major	7 033 (15.5)	6 252 (16.0)	106 (12.1)	184 (13.4)	491 (12.2)
Military pay grade					
Officer	11 693 (25.8)	10 654 (27.3)	149 (17.0)	236 (17.2)	654 (16.2)
Enlisted	33 579 (74.2)	28 339 (72.7)	729 (83.0)	1137 (82.8)	3374 (83.8)
Service component					
Active duty	25 274 (55.8)	21 461 (55.0)	508 (57.9)	889 (64.8)	2416 (60.0)
Reserve/National Guard	19 998 (44.2)	17 532 (45.0)	370 (42.1)	484 (35.3)	1612 (40.0)
Branch of service					
Army	21 891 (48.4)	18 244 (46.8)	521 (59.3)	780 (56.8)	2346 (58.2)
Air Force	13 454 (29.7)	12 157 (31.2)	185 (21.1)	283 (20.6)	829 (20.6)
Navy/Coast Guard	8 047 (17.8)	7 176 (18.4)	120 (13.7)	209 (15.2)	542 (13.5)
Marine Corps	1 880 (4.2)	1 416 (3.6)	52 (5.9)	101 (7.4)	311 (7.7)



Table 2 *Cont.*

Characteristic <sup>a</sup>	Study sample (n = 45 272) n (%)	Smokeless tobacco use			
		No use (n = 38 993) n (%)	New use (n = 878) n (%)	Past use (n = 1373) n (%)	Persistent use (n = 4028) n (%)
Occupational category					
Health-care specialists	5 552 (12.3)	5 178 (13.3)	67 (7.6)	87 (6.3)	220 (5.5)
Aircrew	2 240 (5.0)	1 877 (4.8)	54 (6.2)	80 (5.8)	229 (5.7)
Other combat specialists	5 346 (11.8)	3 996 (10.3)	176 (20.1)	264 (19.2)	910 (22.6)
Other	32 134 (71.0)	27 942 (71.7)	581 (66.2)	942 (68.6)	2669 (66.3)
Pre-Iraq/Afghanistan <sup>c</sup>					
1991 Gulf War	3 649 (8.1)	3 076 (7.9)	76 (8.7)	126 (9.2)	371 (9.2)
SW Asia/Bosnia/Kosovo	11 302 (25.0)	9 415 (24.2)	247 (28.1)	441 (32.1)	1199 (29.8)
Both	2 224 (4.9)	1 863 (4.8)	50 (5.7)	69 (5.0)	242 (6.0)
Neither	28 097 (62.1)	24 639 (63.2)	505 (57.5)	737 (53.7)	2216 (55.0)
Iraq/Afghanistan deployment <sup>f</sup>					
Non-deployed	32 760 (72.4)	28 901 (74.1)	510 (58.1)	909 (66.2)	2440 (60.6)
Deployed once	9 581 (21.2)	7 734 (19.8)	283 (32.2)	359 (26.2)	1205 (29.9)
Deployed multiple times	2 931 (6.5)	2 358 (6.1)	85 (9.7)	105 (7.7)	383 (9.5)
Iraq/Afghanistan combat exposure					
Non-deployed	32 760 (72.4)	28 901 (74.1)	510 (58.1)	909 (66.2)	2440 (60.6)
Deployed without combat	6 204 (13.7)	5 321 (13.7)	134 (15.3)	186 (13.6)	563 (14.0)
Deployed with combat	6 308 (13.9)	4 771 (12.2)	234 (26.7)	278 (20.3)	1025 (25.5)

PTSD: post-traumatic stress disorder. <sup>a</sup>All differences in distribution by deployment status were statistically significant at  $P < 0.001$ . <sup>b</sup>Alcohol-related problem based on affirmative response to any alcohol question on the Patient Health Questionnaire or Cut-down, Annoyed, Guilt, Eye-opener (CAGE) questionnaire. <sup>c</sup>Post-traumatic stress disorder based on screening positive on the PTSD Patient Checklist—Civilian Version using criteria from the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition. <sup>d</sup>Self-report of a physician diagnosis for depression, schizophrenia, psychosis or manic-depressive disorder. <sup>e</sup>Deployment prior to the wars in Iraq and Afghanistan includes the 1991 Gulf War, and Southwest Asia following the 1991 Gulf War, Bosnia or Kosovo from 1998 to 2000. <sup>f</sup>Both indicates deployment to 1991 Gulf War and Southwest Asia, Bosnia or Kosovo, while 'neither' implies not deployed to any of these operations. <sup>g</sup>Number of deployments to Iraq or Afghanistan between baseline and follow-up questionnaires.

## DISCUSSION

To our knowledge, this study is the first to assess ST use in a prospective population-based setting spanning all US military service branches and components while examining the effects of deployment, combat exposure, occupation, smoking status and mental health symptoms. Using a large sample size, we found that both exposure to combat and the frequency of deployments increased the odds of ST initiation and persistence. This study also confirmed prior findings that younger, male, less educated and Army or Marine Corps populations are more likely to begin ST use [2,26,27]. In addition, ST uptake was associated with PTSD symptoms, as well as alcohol and smoking, which highlights the complex relations between health-related behaviors and mental disorders.

This is the first large, prospective study to report finding deployment and combat exposure associated positively with ST initiation and persistent use. Explanations for this finding include the use of ST to reduce boredom or stress [28]; as a substitute for cigarette smoking when the glow, smoke or smell of a cigarette may expose troops to the enemy; or when smoking is forbidden near explosive

ordinance, in buildings or aboard aircraft. Additionally, those exposed to combat were at significantly increased odds for both ST initiation and persistent use. This may indicate that ST use during and following combat deployment may be a coping mechanism for stress, or act as one of a host of risk-taking behaviors observed among those who have experienced combat stress [29].

Stress has been demonstrated previously to contribute to both initiating and increasing ST use in military personnel [28,30]. Tobacco initiation is increasingly implicated as perpetuating a stress response in users, thereby increasing risk for recurrent use. The role of stress is underscored by the finding of increased odds of ST initiation in participants with stress-related symptoms associated with PTSD. In addition, symptoms of PTSD can closely resemble nicotine withdrawal to the novice ST user and thus reinforce sustained use to relieve falsely perceived symptoms of nicotine withdrawal [31].

The relation between ST and the other major tobacco delivery system, smoking, may also support the role of stress in tobacco use. ST use is correlated highly with smoking in other studies, as evidenced by an OR of 3.01 for daily ST use in baseline smokers [11]. In the current

**Table 3** Adjusted odds of smokeless tobacco use among 45 272 Millennium Cohort Study participants, 2001–06.

<i>Characteristic</i>	<i>Smokeless tobacco initiation among non-users<sup>a</sup></i>		<i>Persistent use of smokeless tobacco among users<sup>b</sup></i>	
	<i>AOR (95% CI)<sup>c</sup></i>	<i>Beta (SD)</i>	<i>AOR (95% CI)<sup>c</sup></i>	<i>Beta (SD)</i>
<b>Sex</b>				
Female	1.00		1.00	
Male	8.28 (6.07–11.29)	2.11 (0.16)	3.45 (2.43–4.91)	1.24 (0.18)
<b>Birth cohort</b>				
Pre-1960	1.00		1.00	
1960–69	2.06 (1.63–2.61)	0.72 (0.12)	1.15 (0.92–1.45)	0.14 (0.12)
1970–79	3.46 (2.67–4.49)	1.24 (0.13)	1.07 (0.84–1.37)	0.07 (0.13)
1980+	5.76 (3.93–8.44)	1.75 (0.20)	0.82 (0.57–1.17)	–0.20 (0.18)
<b>Education</b>				
High school or less	1.00		1.00	
Some college/bachelor's	0.87 (0.71–1.06)	–0.14 (0.10)	0.94 (0.77–1.14)	–0.07 (0.10)
Advanced degree	0.59 (0.38–0.91)	–0.53 (0.22)	0.69 (0.46–1.03)	–0.37 (0.20)
<b>Marital status</b>				
Never married	1.00		1.00	
Currently married	1.11 (0.93–1.33)	0.11 (0.09)	1.24 (1.05–1.46)	0.22 (0.08)
No longer married	0.74 (0.49–1.12)	–0.30 (0.21)	1.09 (0.80–1.48)	0.09 (0.16)
<b>Race/ethnicity</b>				
White non-Hispanic	1.00		1.00	
Black non-Hispanic	0.39 (0.28–0.54)	–0.94 (0.17)	0.45 (0.31–0.65)	–0.81 (0.19)
Asian/Pacific Islander	0.91 (0.68–1.21)	–0.10 (0.15)	0.78 (0.58–1.05)	–0.24 (0.15)
Other	0.55 (0.41–0.74)	–0.60 (0.15)	0.59 (0.45–0.76)	–0.53 (0.13)
<b>Smoking</b>				
Never smokers	1.00		1.00	
Past smokers	1.93 (1.58–2.36)	0.66 (0.10)	0.78 (0.66–0.92)	0.25 (0.08)
Recidivists/initiators	4.65 (3.82–5.66)	1.54 (0.10)	0.89 (0.73–1.09)	–0.12 (0.10)
Persistent smokers	3.16 (2.61–3.82)	1.15 (0.10)	0.56 (0.47–0.67)	–0.59 (0.09)
<b>Alcohol-related problem<sup>d</sup></b>				
No	1.00		1.00	
Yes	1.21 (1.04–1.41)	0.19 (0.08)	1.10 (0.97–1.26)	0.10 (0.07)
<b>PTSD symptoms<sup>e</sup></b>				
No	1.00		1.00	
Yes	1.54 (1.15–2.07)	0.43 (0.15)	0.95 (0.70–1.27)	0.06 (0.15)
<b>Past mental health diagnosis<sup>f</sup> or taking medication for anxiety, depression or stress</b>				
No	1.00		1.00	
Yes	0.96 (0.73–1.27)	–0.04 (0.14)	0.82 (0.63–1.06)	–0.20 (0.13)
<b>Life stressors score</b>				
Low/mild	1.00		1.00	
Moderate/major	0.95 (0.76–1.18)	–0.06 (0.11)	0.96 (0.79–1.17)	–0.04 (0.10)
<b>Military pay grade</b>				
Officer	1.00		1.00	
Enlisted	0.95 (0.73–1.23)	–0.06 (0.13)	1.03 (0.79–1.35)	0.03 (0.13)
<b>Service component</b>				
Active duty	1.00		1.00	
Reserve/National Guard	1.18 (1.00–1.39)	0.17 (0.08)	1.15 (0.99,1.35)	0.14 (0.08)
<b>Branch of service</b>				
Army	1.00		1.00	
Air Force	0.69 (0.55–0.86)	–0.37 (0.11)	0.96 (0.77–1.19)	–0.05 (0.11)
Navy/Coast Guard	0.65 (0.52–0.80)	–0.44 (0.11)	0.90 (0.74–1.10)	–0.11 (0.10)
Marine Corps	0.94 (0.69–1.28)	–0.06 (0.16)	1.06 (0.82–1.36)	0.06 (0.13)
<b>Occupational category</b>				
Health-care specialists	1.00		1.00	
Aircrew	1.39 (0.94–2.07)	0.33 (0.20)	0.90 (0.61–1.33)	–0.11 (0.20)
Other combat specialists	1.24 (0.92–1.68)	0.22 (0.15)	1.15 (0.85–1.55)	0.14 (0.15)
Other	0.91 (0.70–1.19)	–0.09 (0.14)	0.99 (0.75–1.31)	–0.01 (0.14)

Table 3 Cont.

Characteristic	Smokeless tobacco initiation among non-users <sup>a</sup>		Persistent use of smokeless tobacco among users <sup>b</sup>	
	AOR (95% CI) <sup>c</sup>	Beta (SD)	AOR (95% CI) <sup>c</sup>	Beta (SD)
Pre-Iraq/Afghanistan deployment <sup>g</sup>				
1991 Gulf War	1.13 (0.87–1.47)	0.12 (0.13)	0.82 (0.65–1.04)	–0.19 (0.12)
SW Asia/Bosnia/Kosovo	0.94 (0.79–1.18)	0.06 (0.09)	0.87 (0.74–1.02)	0.14 (0.08)
Both	1.17 (0.85–1.60)	0.16 (0.16)	1.06 (0.78–1.43)	0.06 (0.15)
Neither	1.00		1.00	
Iraq/Afghanistan combat exposure				
Non-deployed	1.00		1.00	
Deployed without exposure	1.31 (1.07–1.60)	0.27 (0.10)	1.18 (0.98–1.44)	0.17 (0.10)
Deployed with exposure	1.76 (1.49–2.09)	0.57 (0.09)	1.43 (1.21–1.68)	0.35 (0.08)
Iraq/Afghanistan deployment <sup>h</sup>				
Non-deployed	1.00		1.00	
Deployed once	1.53 (1.31–1.79)	0.43 (0.08)	1.30 (1.12–1.50)	0.26 (0.07)
Deployed multiple times	1.67 (1.31–2.14)	0.51 (0.13)	1.44 (1.13–1.83)	0.36 (0.12)

AOR: adjusted odds ratio; CI: confidence interval. <sup>a</sup>Among non-users at baseline, initiation models new use of smokeless tobacco in reference to no use at both time-points. <sup>b</sup>Among smokeless tobacco users at baseline, persistence models subsequent use of smokeless tobacco in reference to those who did not report use at follow-up. <sup>c</sup>Odds of smokeless tobacco use are adjusted for all variables listed. <sup>d</sup>Alcohol-related problem based on affirmative response to any alcohol question on the Patient Health Questionnaire or Cut-down, Annoyed, Guilt, Eye-opener (CAGE) questionnaire. <sup>e</sup>Post-traumatic stress disorder (PTSD) based on screening positive on the PTSD Patient Checklist—Civilian Version using criteria from the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition. <sup>f</sup>Self-report of a physician diagnosis for depression, schizophrenia, psychosis or manic-depressive disorder. <sup>g</sup>Deployment prior to the wars in Iraq and Afghanistan includes the 1991 Gulf War, and Southwest Asia, Bosnia or Kosovo from 1998 to 2000. <sup>h</sup>Number of deployments to Iraq or Afghanistan between baseline and follow-up questionnaires.

study, individuals who were smoking initiators, recidivists, persistent or past users were at increased odds of initiating ST use compared with never smokers. The important association between smoking and ST use found here is supported by several other studies [11,32,33]. It is interesting that past smokers and persistent smokers were at decreased odds of persistent ST use, given the strong co-occurrence between cigarette smoking and ST use [34,35]. It is plausible that individuals who quit smoking successfully were also able to prevent themselves from becoming persistent ST users. Persistent smokers may be satisfied with their current nicotine delivery method and have little need to supplement smoking with smokeless tobacco.

The positive association between ST use and problematic alcohol consumption use in this study is supported by previous research on military personnel [32,36,37]. Shared social influences between alcohol and nicotine-using populations may explain some of these findings, as might shared neurobiology of stress and drug reward systems between nicotine and alcohol use disorders [38]. Data support a role for activated stress systems in alcohol withdrawal [39]. In addition, alcohol may reduce withdrawal-related stress in nicotine withdrawal and vice versa.

Contrary to our a priori hypothesis, military occupation was not related to ST use in adjusted models as neither aircrew nor combat specialists displayed

increased odds of ST use after adjustment in multivariable models. These findings are in contrast to prior studies that showed a higher prevalence of ST use in military aviators [37,40]. This may be due to difficulty ascertaining a precise time for ST initiation and the challenge of accurately capturing the occupation of deployed individuals who may perform multiple functions that cross standard occupational categories, or perhaps differences in reference categories used between studies.

This study has some limitations. A stratified sampling design was used to invite study subjects, and results may not reflect those obtained from a random or complete sample of all eligible subjects. However, the models presented in Table 3 provide estimates that are adjusted for this oversampling. In addition, a large number of subjects either did not receive an invitation or decided not to respond to our initial invitation, and response to a follow-up invitation was less than complete. Additionally, we removed those in the current analysis with missing data at follow-up. Characteristics of non-response to follow-up include a history of smoking, chronic alcohol consumption or a major depressive disorder, or having separated from military service at follow-up. We conducted a missing data analysis comparing the study sample to the cohort as a whole which showed little evidence to suggest any notable bias including a lack of significant differences in both deployment and ST use variables. Moreover, previous analyses have demon-

strated that Millennium Cohort participants well represent the US military [16,41,42], prior health status did not influence response rates [43] and questionnaire data are reliable [44–46]. Inverse probability weighting has also found no appreciable bias as a result of non-response in past studies [47]. Due to the scope of the study, gold standard assessments of variables such as tobacco use, psychiatric diagnosis, alcohol use and PTSD symptoms could not be employed and are measured by self-report, which is open to bias. For instance, self-report of ST use and cigarette smoking is inherently susceptible to reporting bias. However, the magnitude of this bias is likely to be small, given that self-report of the use of tobacco including ST has been found to have a sensitivity of 90% and specificity of 93% compared with measurement by saliva cotinine concentration [48].

In summary, initiation and persistence of smokeless tobacco was associated with features of military service, especially deployment to Iraq or Afghanistan with or without combat exposure. While research supports that PTSD, depression, substance use disorders and mild traumatic brain injury are hallmarks of the conflicts, this is the first study to suggest ST specifically as another such consequence [17,49]. Given the significant risk for tobacco addiction and its myriad long-term and costly health consequences, the potential impact of these findings is significant. This study will aid future research to identify features of deployment and military service amenable to interventions designed to reduce or prevent adoption and persistence of ST. Future research may also assess the potential risk for mild traumatic brain injury to increase risk for ST initiation and persistence. For tobacco prevention and treatment strategies already in place, factors such as deployment, combat exposure, smoking, PTSD symptoms, alcohol consumption and current predictors of ST cessation should be considered to tailor these efforts more effectively.

### Declarations of interest

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